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(54) FLIGHT VEHICLE, PROPULSION SYSTEM AND THRUST VECTORING SYSTEM

FLUGZEUG, ANTRIEBSSYSTEM UND SCHUBVEKTORISIERUNGSSYSTEM

VÉHICULE DE VOL, SYSTÈME DE PROPULSION ET SYSTÈME D’ORIENTATION DE POUSSÉE

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Description

Field of the Invention

[0001] The present invention relates to flight vehicles, and more particularly, to propulsion systems and thrust vectoring systems for flight vehicles.

Background

[0002] Flight vehicles, flight vehicle propulsion systems and flight vehicle thrust vectoring systems remain an area of interest. Some existing systems have various shortcomings, drawbacks, and disadvantages relative to certain applications.

[0003] Accordingly, there remains a need for further contributions in this area of technology.

[0004] US 2007/0266712 A1 discloses a propulsion gas exhaust assembly in an aircraft propelled by hot gases produced along the axis of the latter by a gas generator, comprising a duct and a nozzle, wherein the duct forms a vertical elbow.

[0005] US 2008/0149742 A1 discloses a system for control input prediction and state verification of an aircraft's fluidic vectoring exhaust.

Summary

[0006] According to an aspect of the present invention, there is provided a propulsion system according to claim 1.

Brief Description of the Drawings

[0007] The description herein makes reference to the accompanying drawings wherein like reference numerals refer to like parts throughout the several views, and wherein:

FIG. 1 schematically illustrates some aspects of a non-limiting example of a flight vehicle.

FIGS. 2A-2E schematically illustrate some aspects of a non-limiting example of a propulsion system in accordance with an embodiment of the present invention.

FIGS. 3A-3F schematically illustrate some combinations of activated fluidic injectors in a nozzle system for providing thrust vectoring in various directions in accordance with an embodiment of the present invention.

FIGS. 4A-4C schematically illustrate thrust vectors produced by the propulsion system of FIGS. 2A-2E with various combinations of activated fluidic injectors illustrated in FIGS. 3A-3F.

Detailed Description

[0008] For purposes of promoting an understanding of the principles of the invention, reference will now be made to the embodiments illustrated in the drawings, and specific language will be used to describe the same. It will nonetheless be understood that no limitation of the scope of the invention is intended by the illustration and description of certain embodiments of the invention. In addition, any alterations and/or modifications of the illustrated and/or described embodiment(s) are contemplated as being within the scope of the present invention. Further, any other applications of the principles of the invention, as illustrated and/or described herein, as would normally occur to one skilled in the art to which the invention pertains, are contemplated as being within the scope of the present invention.

[0009] Referring to the drawings, and in particular FIG. 1 , some aspects of a non-limiting example of a flight vehicle 10 are schematically depicted. In one form, vehicle 10 is an air-vehicle, e.g., such as a fixed-wing aircraft. In other examples, vehicle 10 may be any airborne and/or space-borne vehicle, e.g., such as a missile, a rocket, a spacecraft or a satellite, or may be a waterborne vehicle, such as a surface vessel or a subsurface vessel. In one form, vehicle 10 includes one or more flight structures 12, e.g., one or more of a fuselage, a wing, an empennage or another flight structure. In other examples, flight structure 12 may take other forms, whether lift-producing or not. In one form, vehicle 10 includes two propulsion systems 20. In other examples, vehicle 10 may include a greater or lesser number of propulsion systems.

[0010] Referring to FIGS. 2A-2E, a non-limiting example of a propulsion system 20 in accordance with an embodiment of the present invention is schematically depicted. Propulsion system 20 is operative to provide propulsive thrust to vehicle 10 by discharging a pressurized flow in a primary thrust direction 22 that is generally opposite the direction of travel of vehicle 10. The pressurized flow is a pressurized fluid flow. In one form, the fluid is air and hydrocarbon fuel combustion products. In other embodiments, the fluid may be any vapor, gas and/or liquid. In various forms, propulsion system 20 may be configured to provide primary propulsion for vehicle 10 and/or to provide steering thrust. All or a portion of propulsion system 20 may be covered, e.g., by a cowling (not shown), in order to reduce parasitic drag. As illustrated in the top view depicted in FIG. 2A, propulsion system 20 includes an engine 30, a transition duct 40 and a nozzle system 50.

[0011] Nozzle system 50 includes a nozzle 52. In one form, nozzle 52 is a converging nozzle. In one form, nozzle system 50 also includes a diverging nozzle 54, and in such embodiments, nozzle system 50 is in the form of a supersonic converging-diverging nozzle. In one form, diverging nozzle 54 is a single expansion ramp nozzle having a single expansion ramp 56. In other embodiments, diverging nozzle 54 may take other forms. In still other embodiments, nozzle system 50 may not include a converging nozzle and/or may not include a diverging nozzle, e.g., wherein nozzle system 50 is configured to direct flow without respectively contracting and/or expanding the flow area along the length of nozzle system 50.

[0012] Engine 30 is mounted to flight structure 12. Engine 30 is operative to generate a pressurized flow for discharge via nozzle system 50 for providing propulsive thrust to flight structure 12. In one form, engine 30 is a gas turbine engine. In other embodiments, engine 30 may be any engine or system operative to provide a pressurized flow suitable for use in providing propulsion and/or vectoring thrust to an airborne and/or space-born vehicle or a water-borne vehicle.

[0013] Transition duct 40 is in fluid communication with engine 30 and with converging nozzle 52. Transition duct 40 is configured to transition the pressurized airflow from one flow area geometry, e.g., an annular flow area at the discharge of engine 30, to the flow area geometry corresponding to the inlet of converging nozzle 52, for example, as illustrated in the side view depicted in FIG. 2B. In one form, transition duct 40 has a constant flow area, changing only in flow area shape from one point to another along its length. In other embodiments, transition duct may include portions having constant flow area and/or have portions configured expand and/or contract the flow area. For example, in some embodiments, transition duct 40 may be considered a part of nozzle 52.

[0014] Nozzle system 50 is configured to receive pressurized flow provided by engine 30. In one form, nozzle system 50 is configured to accelerate the pressurized flow. In other embodiments, nozzle system may not be configured to accelerate the pressurized flow. Nozzle system 50 includes an inflected throat 70 formed at the end of converging nozzle 52. In one form, nozzle system 50 is a high aspect ratio nozzle, e.g., having a substantially greater width than height. In one form, throat 70 includes an inflection 72, a throat portion 74 and a throat portion 76. In one form, throat portion 74 and throat portion 76 are linear. In other embodiments, inflected throat 70 may have more than one inflection, and/or may have linear and/or curved throat portions extending in one or more directions between each pair of inflections and between the inflections and the outer extents of throat 70 adjacent thereto. Also, in other embodiments, throat 70 may have more than two throat portions. Throat portion 74 extends from one side of inflection 72, and has a throat area A1. Throat portion 76 extends from the other side of inflection 72, and has a throat area A2. In one form, throat areas A1 and A2 are the same in magnitude. In other embodiments, throat areas A1 and A2 may be different in magnitude.

[0015] In one form, throat 70 is continuous, i.e., not partitioned to separate throat portions such as throat portions 74 and 76 from each other. In other embodiments, throat 70 may not be continuous, and may include, for example, one or more partitions to separate throat portions, e.g., a partition located at inflection 72 to separate throat portions 74 and 76. In one form, throat portions 74 and 76 lie in a common plane, e.g., a plane parallel to the view of FIG. 2A. In other embodiments, throat portions 74 and 76 may lie in different planes, e.g., intersecting planes, for example, forming a "V" shape or an inverted "V" shape when viewed in the direction of FIG. 2C. In yet other embodiments, one or more additional throat portions may extend from inflection 72 in one or more additional planes that intersect(s) with the planes in which in which throat portions 74 and 76 lie, for example, forming an "X" shape, a "Y" or inverted "Y" shape, or a "+" shape when viewed in the direction of FIG. 2C. In still other embodiments, throat 70 may include throat portions that extend in planes that are parallel to each other. In embodiments wherein nozzle system 50 is configured to direct flow without contracting and/or expanding the flow area along the length of nozzle system 50, inflected throat 70 is considered the portion of nozzle 52 adjacent the nozzle outlet.

[0016] Throat portion 74 and throat portion 76 each face in different directions. For example, in the embodiment shown in FIG. 2A, throat portion 74 is oriented in direction 77 at an angle $\Phi 1$ relative to the centerline 78 of nozzle system 50. Throat portion 76 is oriented in direction 79 at an angle $\Phi 2$ relative to the centerline 78 of nozzle system 50. In one form, directions 77 and 79 are yaw directions, wherein a thrust component in either direction 77 or 79 provide a yaw moment to vehicle 10. In other embodiments, directions 77 and 79 may be pitch directions and/or roll directions that yield respective pitch and/or roll moments to vehicle 10. In one form, angles $\Phi 1$ and $\Phi 2$ form a concave throat 70, e.g., concave and open to the right in the view of FIG. 2A, e.g., wherein inflection 72 is positioned to the left of throat portions 74 and 76. In other embodiments, angles $\Phi 1$ and $\Phi 2$ may be selected to provide a convex shape, e.g., wherein inflection 72 would be positioned to the right of throat portions 74 and 76 in FIG. 2A.

[0017] Nozzle system 50 is configured to selectively discharge the pressurized flow in direction 22. In addition, nozzle system 50 is configured to discharge a first portion of the pressurized airflow from throat portion 74 in one direction, i.e., toward direction 77; and to discharge a second portion of the pressurized airflow from the second throat portion in a different direction, i.e., toward direction 79. In some embodiments, either throat portion 74 or throat portion 76 may be perpendicular to centerline 78 or be otherwise oriented to direct pressurized flow in direction 22, whereas the other of throat portion 74 and throat portion 76 may be oriented at some non-ninety degree angle from centerline 78.

[0018] Converging nozzle 52 includes ramps (walls) 58, 59, 60, 61, 62 and 63 that define the flowpath for the pressurized flow within converging nozzle 52. Ramps 58 and 61 form upper flowpath boundaries; ramps 59 and 62 form lower flowpath boundaries; and ramps 60 and

63 form lateral flowpath boundaries. Ramp 60 is adjacent to throat portion 74. Ramp 63 is adjacent to throat portion 76. It will be understood that the terms, "upper," "lower" and "lateral" are intended to convey only relative relationships between the ramps that form converging nozzle 52 in the context of the illustrated example, not absolute positions of the ramps. It will also be understood that embodiments of the present invention may include any number of ramps having any orientation suitable for the particular application(s). In one form, ramps 58, 59, 61 and 62 are configured to shield the discharge of engine 30 from direct view, e.g., by being curved in the manner depicted in FIGS. 3D and 2E, to reduce the heat signature of propulsion system 20 and vehicle 10. In other embodiments, ramps 58, 59, 61 and 62 may not be so configured.

[0019] Ramp 60 and throat portion 74 are configured to direct a portion of the pressurized flow toward direction 77. In one form, ramp 60 extends toward direction 77 to help guide flow exiting throat portion 74 toward direction 77 for providing vectored thrust toward direction 77. In other embodiments, ramp 60 may extend in another direction to facilitate thrust vectoring in a desired direction. In still other embodiments, ramp 60 may extend parallel to centerline 78. Ramp 63 and throat portion 76 are configured to direct a portion of the pressurized flow toward direction 79. In one form, ramp 63 extends toward direction 79 to help guide flow exiting throat portion 76 toward direction 79 for providing vectored thrust toward direction 79. In other embodiments, ramp 63 may extend in another direction to facilitate thrust vectoring in a desired direction. In still other embodiments, ramp 63 may extend parallel to centerline 78.

[0020] Referring to FIGS. 3A, 3B and 4A in conjunction with FIGS. 2A-2E, nozzle system 50 includes a fluidic injection zone 80 and a fluidic injection zone 82. Disposed with fluidic injection zone 80, proximate to throat portion 74, is a fluidic injector arrangement 84. Fluidic injector arrangement 84 is operative to alter the flow through throat portion74. In one form, injector arrangement 84 includes an independently controllable fluidic injector 90 and an independently controllable fluidic injector 92. In other embodiments, a greater or lesser number of fluidic injectors may be employed. In one form, fluidic injector 90 and fluidic injector 92 are disposed proximate to throat portion 74 on opposite sides of throat portion 74.

[0021] Fluidic injectors 90 and 92 are operative to selectively inject fluid F1 and F2, e.g., pressurized flow received from engine 30 (for example, engine discharge flow and/or compressor/fan interstage and/or discharge flow), into the pressurized flowstream passing through nozzle 52 in proximity to throat portion 74 in order to effect thrust vectoring. In one form, fluidic injectors 90 and 92 are independently controllable by valves (not shown), and may be selectively activated via a control system (not shown).

[0022] In one form, fluidic injector arrangement 84 is configured to reduce flow through throat portion 74 by activating one or both of fluidic injectors 90 and 92 to inject fluid into the flowpath extending through throat portion 74. In one form, fluidic injectors 90 and 92 are positioned to inject fluid into the flowpath upstream of throat portion 74. In other embodiments, fluidic injectors 90 and 92 may be positioned to inject fluid in the flowpath at throat portion 74 and/or downstream of throat portion 74 in addition to or in place of fluidic injection upstream of throat portion 74.

[0023] The reduction in flow through throat portion 74 results in an increase in flow through throat portion 76, providing vectored thrust toward direction 79, which generates a moment, e.g., a yaw moment. Inflected throat 70 reduces the amount of fluidic injection required to vector thrust toward direction 79 relative to nozzles that do not have an inflected throat, e.g., since the angling of throat portion 76 tends to direct flow toward direction 79, and since the angled throat portion 76 yields a lateral pressure component at the outlet of converging nozzle 52, e.g., a pressure component directed toward centerline 78.

[0024] Disposed with fluidic injection zone 82, proximate to throat portion 76, is a fluidic injector arrangement 86. Fluidic injector arrangement 86 is operative to alter the flow through throat portion 76. In one form, injector arrangement 86 includes an independently controllable fluidic injector 94 and an independently controllable fluidic injector 96. In other embodiments, a greater or lesser number of fluidic injectors may be employed. In one form, fluidic injector 94 and fluidic injector 96 are disposed proximate to throat portion 76 on opposite sides of throat portion 76. Fluidic injectors 94 and 96 are operative to selectively inject fluid F3 and F4, e.g., pressurized flow received from engine 30 (for example, engine discharge flow and/or compressor/fan interstage and/or discharge flow), into the pressurized flowstream passing through converging nozzle 52 in proximity to throat portion 76 in order to effect thrust vectoring. In one form, fluidic injectors 94 and 96 are independently controllable by valves (not shown), and may be selectively activated via a control system (not shown). In one form, fluidic injector arrangement 86 is configured to reduce flow through throat portion 76 by activating one or both of fluidic injectors 94 and 96 to inject fluid into the flowpath extending through throat portion 76.

[0025] In one form, fluidic injectors 94 and 96 are positioned to inject fluid into the flowpath upstream of throat portion 76. In other embodiments, fluidic injectors 94 and 96 may be positioned to inject fluid in the flowpath downstream of throat portion 76 in addition to or in place of fluidic injectors upstream of throat portion 76. The reduction in flow through throat portion 76 results in an increase in flow through throat portion 74, providing vectored thrust toward direction 77, which generates a moment, e.g., a yaw moment. Inflected throat 70 reduces the amount of fluidic injection required to vector thrust in direction 77 relative to nozzles that do not have an inflected throat, e.g., since the angling of throat portion 76 tends to direct flow toward direction 79, and since the angled throat portion 76 yields a lateral pressure component at the outlet of converging nozzle 52, e.g., a pressure component directed toward centerline 78.

[0026] Nozzle system 50 is configured to direct thrust in primary thrust direction 22 when fluidic injectors 90, 92, 94 and 96 are not activated. Nozzle system 50 may be configured to direct thrust to generate yaw, pitch and/or roll moments, e.g., as set forth herein. For example, nozzle system 50 is configured to provide vectored thrust in the yaw direction, e.g., as set forth above, by selectively activating either fluidic injectors 90 and 92, or fluid injectors 94 and 96.

[0027] In various embodiments, performing fluidic injection via different combinations of fluidic injectors may be used to provide yaw, pitch and/or roll control of vehicle 10 via propulsion system 20, for example, as illustrated in FIGS. 3A-3F and FIGS. 4A-4C. FIGS. 3A-3F depict an aft end view of propulsion system 20, having a direction of view similar to the direction of view of FIG. 2C. FIGS. 3A-3F schematically illustrate some different combinations of fluidic injectors that may be employed to provide yaw, pitch and roll control of vehicle 10. Other embodiments may use other combinations of a greater or lesser number of fluidic injectors to provide yaw, pitch and/or roll control of vehicle 10. FIG. 4A represents a top view of part of propulsion system 20, having a direction of view similar to that of FIGS. 1 and 2A. FIG. 4B represents an aft end view of part of propulsion system 20, having a direction of view similar to that of FIG 2B. FIG. 4C represents an aft end view of part of propulsion system 20, having a direction of view similar to that of FIG 2C.

[0028] In one form, nozzle system 50 is configured generate a yaw moment in yaw direction 150 by increasing flow through throat portion 74 by activating one or both of fluidic injectors 94 and 96 to reduce flow through the throat portion 76. In one form, nozzle system 50 is also configured generate a yaw moment in yaw direction 152 by increasing flow through throat portion 76 by activating one or both of fluidic injectors 90 and 92 to reduce flow through throat portion 74. In one form, fluidic injectors 90 and 92 cooperate to reduce flow through the throat portion 74, and fluidic injectors 94 and 96 cooperate to reduce flow through the throat portion 76. In other embodiments, only one of fluidic injectors 90 and 92 may be employed to reduce flow through throat portion 74, and only one of fluidic injectors 94 and 96 may be employed to reduce flow through throat portion 76. Fluidic injection through fluidic injectors 90 and 92 is operative to direct a portion of the pressurized airflow in converging nozzle 52 toward direction 79, generating a yaw moment in yaw direction 152. Fluidic injection through fluidic injectors 94 and 96 is operative to direct a portion of the pressurized airflow in converging nozzle 52 toward direction 77, generating a yaw moment in yaw direction 150. Thus, as illustrated in FIGS. 3A, 3B and 4A, propulsion system 20 generates a yaw moment in one yaw direction by performing fluidic injection through a first combination of the fluidic injectors, and generates a yaw moment in a second yaw direction by performing fluidic injection through a second combination of the fluidic injectors.

[0029] In one form, nozzle system 50 is also configured to generate pitch moments in different directions. For example, referring to FIGS. 3C, 3D and 4B, nozzle system 50 is configured to generate a pitch moment in pitch direction 162 by activating the fluidic injectors 90 and 94, which directs flow, illustrated by arrow 166, through the portion of throat 70 adjacent to single expansion ramp 56. In some embodiments, nozzle system 50 is also configured to generate a pitch moment in pitch direction 160 by activating fluidic injectors 92 and 96, which directs flow, illustrated by arrow 168, through a portion of throat 70 opposite to single expansion ramp 56. Thus, in one form, propulsion system 20 generates a pitch moment in one pitch direction by performing fluidic injection through a third combination of the fluidic injectors; and generates a pitch moment in another pitch direction by performing fluidic injection through a fourth combination of the fluidic injectors.

[0030] In some embodiments, nozzle system 50 may also be configured to generate roll moments in different directions. For example, referring to FIGS. 3E, 3F and 4C, nozzle system 50 may be configured to generate a roll moment in roll direction 172, e.g., by activating the fluidic injectors 90 and 96 to direct some of the pressurized flow through a portion of throat portion 74 adjacent to single expansion ramp 56, e.g., as illustrated by arrow 166; and to direct some of the pressurized flow through a portion of throat portion 76 opposite to single expansion ramp 56, e.g., as illustrated by arrow 168. In addition, in some embodiments, nozzle system 50 may be configured to generate a roll moment in roll direction 170, e.g., by activating the fluidic injectors 92 and 94 to direct some of the pressurized flow through a portion of throat portion 74 opposite to single expansion ramp 56, e.g., as illustrated by arrow 168; and to direct some of the pressurized flow through a portion of throat portion 76 adjacent to single expansion ramp 56, e.g., as illustrated by arrow 166. Thus, nozzle system 50 may be configured to generate a roll moment in one roll direction by performing fluidic injection through a fifth combination of the fluidic injectors, and generate a roll moment in another roll direction by performing fluidic injection through a sixth combination of the fluidic injectors.

[0031] Embodiments of the present invention include a propulsion system as claimed in claim 1.

[0032] In a refinement, the propulsion system further comprises a plurality of independently controllable fluidic injectors, including a first fluidic injector positioned in the first fluidic injection zone proximate to the first throat portion and a second fluidic injector positioned in the second fluidic injection zone proximate to the second throat portion, wherein the first fluidic injector is operable to reduce flow through the first throat portion; and the second fluidic injector is operable to reduce flow through the second throat portion.

[0033] In another refinement, the nozzle system is configured to direct thrust in a primary thrust direction when no fluidic injectors are activated.

[0034] In yet another refinement, the nozzle system is configured generate a yaw moment in a first yaw direction by increasing flow through the first throat portion by activating the second fluidic injector to reduce flow through the second throat portion; and to generate a yaw moment in a second yaw direction by increasing flow through the second throat portion by activating the first fluidic injector to reduce flow through the first throat portion.

[0035] In still another refinement, the propulsion system further comprises: a third fluidic injector in the first fluidic injection zone proximate to the first throat portion and positioned across the first throat portion opposite to the first fluidic injector; and a fourth fluidic injector in the second fluidic injection zone proximate to the second throat portion and positioned across the second throat portion opposite to the second fluidic injector, wherein the nozzle system is configured to: generate a yaw moment in a first yaw direction by increasing flow through the first throat portion by activating the second fluidic injector and the fourth fluidic injector to reduce flow through the second throat portion; and to generate a yaw moment in a second yaw direction by increasing flow through the second throat portion by activating the first fluidic injector and the third fluidic injector to reduce flow through the first throat portion; and generate a pitch moment in a first pitch direction by activating the first fluidic injector and the second fluidic injector; and to generate a pitch moment in a second pitch direction by activating the third fluidic injector and the fourth fluidic injector.

[0036] In yet still another refinement, the nozzle system is configured to generate a roll moment in a first roll direction by activating the first fluidic injector and the fourth fluidic injector; and to generate a roll moment in a second roll direction by activating the second fluidic injector and the third fluidic injector.

[0037] In a further refinement, the inflected throat is continuous as between the first throat portion and the second throat portion.

[0038] In a yet further refinement, the first throat portion and the second throat portion lie in the same plane.

[0039] While the invention has been described in connection with what is presently considered to be the most practical and preferred embodiment, it is to be understood that the invention is not to be limited to the disclosed embodiments.

[0040] The scope of the present invention is defined by the appended claims. Furthermore it should be understood that while the use of the word preferable, preferably, or preferred in the description above indicates that feature so described may be more desirable, it nonetheless may not be necessary and any embodiment lacking the same may be contemplated as within the scope of the invention, that scope being defined by the claims that follow. In reading the claims it is intended that when words such as "a," "an," "at least one" and "at least a portion" are used, there is no intention to limit the claim to only one item unless specifically stated to the contrary in the claim. Further, when the language "at least a portion" and/or "a portion" is used the item may include a portion and/or the entire item unless specifically stated to the contrary.

Claims

1. A propulsion system (20), comprising:

    an engine (30) configured to discharge a pressurized flow;

    a nozzle system (50) configured to receive a pressurized flow, wherein the nozzle system (50) includes a nozzle (52, 54), an inflected throat (70) and at least two fluidic injection zones (80, 82);

    characterized in that the inflected throat (70) includes a first throat portion (74) having a first throat flow area, and a second throat portion (76) having a second throat flow area, wherein the first throat portion (74) and the second throat portion (76) face different directions,

    wherein the nozzle system (50) is configured to discharge a first portion of the pressurized flow from the first throat portion (74) in a first direction by reducing flow through the second throat portion (76) using at least a second fluidic injection zone (82), and to discharge a second portion of the pressurized flow from the second throat portion (76) in a second direction different from the first direction by reducing flow through the first throat portion (74) using at least a first fluidic injection zone (80);

    wherein the first throat portion (74) extends from one side of an inflection (72) of the throat, and wherein the second throat portion (76) extends from another side of the inflection of the throat.

2. The propulsion system (20) of claim 1, further comprising a plurality of independently controllable fluidic injectors (90, 92, 94, 96), including a first fluidic injector (90) positioned in the first fluidic injection zone (80) proximate to the first throat portion (74) and a second fluidic injector (94) positioned in the second fluidic injection zone (82) proximate to the second throat portion (76), wherein the first fluidic injector (90) is operable to reduce flow through the first throat portion (74); and the second fluidic injector (94) is operable to reduce flow through the second throat portion (76).

3. The propulsion system (20) of claim 2, wherein the nozzle system (50) is configured to direct thrust in a primary thrust direction when no fluidic injectors are

activated.

4. The propulsion system (20) of claim 2, wherein the nozzle system (50) is configured generate a yaw moment in a first yaw direction by increasing flow through the first throat portion (74) by activating the second fluidic injector (94) to reduce flow through the second throat portion (76); and to generate a yaw moment in a second yaw direction by increasing flow through the second throat portion (76) by activating the first fluidic injector (90) to reduce flow through the first throat portion (74).

5. The propulsion system (20) of claim 2, further comprising:

a third fluidic injector (92) in the first fluidic injection zone (80) proximate to the first throat portion (74) and positioned across the first throat portion (74) opposite to the first fluidic injector (90); and
a fourth fluidic injector (94) in the second fluidic injection zone (82) proximate to the second throat portion (76) and positioned across the second throat portion (76) opposite to the second fluidic injector (94),
wherein the nozzle system (50) is configured to:

generate a yaw moment in a first yaw direction by increasing flow through the first throat portion (74) by activating the second fluidic injector (94) and the fourth fluidic injector (94) to reduce flow through the second throat portion (76); and to generate a yaw moment in a second yaw direction by increasing flow through the second throat portion (76) by activating the first fluidic injector (90) and the third fluidic injector (92) to reduce flow through the first throat portion (74); and
generate a pitch moment in a first pitch direction by activating the first fluidic injector (90) and the second fluidic injector (94); and to generate a pitch moment in a second pitch direction by activating the third fluidic injector (92) and the fourth fluidic injector (94).

6. The propulsion system (20) of claim 5, wherein the nozzle system (50) is configured to generate a roll moment in a first roll direction by activating the first fluidic injector (90) and the fourth fluidic injector (94); and to generate a roll moment in a second roll direction by activating the second fluidic injector (94) and the third fluidic injector (92).

7. The propulsion system (20) of claim 1, wherein the inflected throat (70) is continuous as between the first throat portion (74) and the second throat portion (76).

8. The propulsion system (20) of claim 1, wherein the first throat portion (74) and the second throat portion (76) lie in the same plane.

9. The propulsion system (20) any preceding claim, wherein the centerline of inflected throat (70) extends through the inflection of the throat and the first throat portion (74) and the second throat portion (76) are each angled toward the centerline.

10. The propulsion system (20) of claim 1, wherein the nozzle (52) is a converging nozzle (52) comprising a first ramp configured to direct the first portion toward a centerline of the nozzle (52) and a second ramp configured to direct the second portion toward the centerline of the nozzle (52).

Patentansprüche

1. Antriebssystem (20), Folgendes beinhaltend:

einen Motor (30), welcher konfiguriert ist, um einen mit Druck beaufschlagten Strom abzulassen;
ein Düsensystem (50), welches konfiguriert ist, um einen mit Druck beaufschlagten Strom aufzunehmen, wobei das Düsensystem (50) eine Düse (52, 54), einen gebeugten Hals (70) und mindestens zwei Fluideinspritzbereiche (80, 82) enthält;
dadurch gekennzeichnet, dass der gebeugte Hals (70) einen ersten Halsabschnitt (74) enthält, welcher einen ersten Halsströmungsbereich besitzt, und einen zweiten Halsabschnitt (76), welcher einen zweiten Halsströmungsbereich besitzt, wobei der erste Halsabschnitt (74) und der zweite Halsabschnitt (76) unterschiedlichen Richtungen zugewandt sind,
wobei das Düsensystem (50) konfiguriert ist, um einen ersten Teil des mit Druck beaufschlagten Stromes vom ersten Halsabschnitt (74) in eine erste Richtung abzulassen durch Reduzieren des Durchflusses durch den zweiten Halsabschnitt (76) unter Verwendung von mindestens einem zweiten Fluideinspritzbereich (82), und um einen zweiten Teil des mit Druck beaufschlagten Stromes vom zweiten Halsabschnitt (76) in eine zweite Richtung abzulassen, welche sich von der ersten Richtung unterscheidet, durch Reduzieren des Durchflusses durch den ersten Halsabschnitt (74) unter Verwendung von mindestens einem ersten Fluideinspritzbereich (80);
wobei sich der erste Halsabschnitt (74) von einer Seite einer Beugung (72) des Halses erstreckt,

und wobei sich der zweite Halsabschnitt (76) von einer anderen Seite der Beugung des Halses erstreckt.

2. Antriebssystem (20) nach Anspruch 1, zudem beinhaltend eine Vielzahl von unabhängig steuerbaren Fluideinspritzem (90, 92, 94, 96), darunter einen ersten Fluideinspritzer (90), welcher in dem ersten Fluideinspritzbereich (80) unmittelbar am ersten Halsabschnitt (74) positioniert ist, und einen zweiten Fluideinspritzer (94), welcher in dem zweiten Fluideinspritzbereich (82) unmittelbar am zweiten Halsabschnitt (76) positioniert ist, wobei der erste Fluideinspritzer (90) betreibbar ist, um Durchfluss durch den ersten Halsabschnitt (74) zu reduzieren; und der zweite Fluideinspritzer (94) betreibbar ist, um Durchfluss durch den zweiten Halsabschnitt (76) zu reduzieren.

3. Antriebssystem (20) nach Anspruch 2, bei welchem das Düsensystem (50) konfiguriert ist, um Schub in eine primäre Schubrichtung zu richten, wenn keine Fluideinspritzer aktiviert sind.

4. Antriebssystem (20) nach Anspruch 2, bei welchem das Düsensystem (50) konfiguriert ist, um ein Giermoment in einer ersten Gierrichtung durch Erhöhen des Durchflusses durch den ersten Halsabschnitt (74) zu erzeugen, durch Aktivieren des zweiten Fluideinspritzers (94) zum Reduzieren des Durchflusses durch den zweiten Halsabschnitt (76); und um ein Giermoment in einer zweiten Gierrichtung durch Erhöhen des Durchflusses durch den zweiten Halsabschnitt (76) zu erzeugen, durch Aktivieren des ersten Fluideinspritzers (90) zum Reduzieren des Durchflusses durch den ersten Halsabschnitt (74).

5. Antriebssystem (20) nach Anspruch 2, zudem Folgendes beinhaltend:

   einen dritten Fluideinspritzer (92) in dem ersten Fluideinspritzbereich (80) unmittelbar am ersten Halsabschnitt (74) und welcher quer über den ersten Halsabschnitt (74) gegenüber dem ersten Fluideinspritzer (90) positioniert ist; und
   einen vierten Fluideinspritzer (94) in dem zweiten Fluideinspritzbereich (82) unmittelbar am zweiten Halsabschnitt (76) und welcher quer über den zweiten Halsabschnitt (76) gegenüber dem zweiten Fluideinspritzer (94) positioniert ist,
   wobei das Düsensystem (50) für folgende Schritte konfiguriert ist:

      Erzeugen eines Giermomentes in einer ersten Gierrichtung durch Erhöhen des Durchflusses durch den ersten Halsabschnitt (74), durch Aktivieren des zweiten Fluideinspritzers (94) und des vierten Fluideinspritzers (94) zum Reduzieren des Durchflusses durch den zweiten Halsabschnitt (76); und
      Erzeugen eines Giermomentes in einer zweiten Gierrichtung durch Erhöhen des Durchflusses durch den zweiten Halsabschnitt (76), durch Aktivieren des ersten Fluideinspritzers (90) und des dritten Fluideinspritzers (92) zum Reduzieren des Durchflusses durch den ersten Halsabschnitt (74); und
      Erzeugen eines Nickmomentes in einer ersten Nickrichtung durch Aktivieren des ersten Fluideinspritzers (90) und des zweiten Fluideinspritzers (94); und Erzeugen eines Nickmomentes in einer zweiten Nickrichtung durch Aktivieren des dritten Fluideinspritzers (92) und des vierten Fluideinspritzers (94).

6. Antriebssystem (20) nach Anspruch 5, bei welchem das Düsensystem (50) konfiguriert ist, um ein Wankmoment in einer ersten Wankrichtung durch Aktivieren des ersten Fluideinspritzers (90) und des vierten Fluideinspritzers (94) zu erzeugen; und um ein Wankmoment in einer zweiten Wankrichtung durch Aktivieren des zweiten Fluideinspritzers (94) und des dritten Fluideinspritzers (92) zu erzeugen.

7. Antriebssystem (20) nach Anspruch 1, bei welchem der gebeugte Hals (70) zwischen dem ersten Halsabschnitt (74) und dem zweiten Halsabschnitt (76) durchgängig ist.

8. Antriebssystem (20) nach Anspruch 1, bei welchem der erste Halsabschnitt (74) und der zweite Halsabschnitt (76) in derselben Ebene liegen.

9. Antriebssystem (20) nach einem der vorhergehenden Ansprüche, bei welchem die Mittellinie des gebeugten Halses (70) sich durch die Beugung des Halses erstreckt und der erste Halsabschnitt (74) und der zweite Halsabschnitt (76) jeweils in Richtung der Mittellinie geneigt sind.

10. Antriebssystem (20) nach Anspruch 1, bei welchem die Düse (52) eine konvergierende Düse (52) ist, welche eine erste Rampe beinhaltet, welche konfiguriert ist, um den ersten Teil in Richtung einer Mittellinie der Düse (52) zu richten und eine zweite Rampe, welche konfiguriert ist, um den zweiten Teil in Richtung der Mittellinie der Düse (52) zu richten.

Revendications

1. Système de propulsion (20), comprenant :

un moteur (30) qui est configuré de manière à ce qu'il décharge un flux sous pression ;
un système d'éjecteur(s) (50) qui est configuré de manière à ce qu'il reçoive un flux sous pression, dans lequel le système d'éjecteur(s) (50) inclut un éjecteur (52, 54), un étranglement fléchi (70) et au moins deux zones d'injection de fluide (80, 82) ;
caractérisé en ce que l'étranglement fléchi (70) inclut une première partie d'étranglement (74) qui présente une première aire de flux d'étranglement et une seconde partie d'étranglement (76) qui présente une seconde aire de flux d'étranglement, dans lequel la première partie d'étranglement (74) et la seconde partie d'étranglement (76) sont orientées selon des directions différentes ;
dans lequel le système d'éjecteur(s) (50) est configuré de manière à ce qu'il décharge une première partie du flux sous pression depuis la première partie d'étranglement (74) dans une première direction en réduisant le flux au travers de la seconde partie d'étranglement (76) en utilisant au moins une seconde zone d'injection de fluide (82) ; et de manière à ce qu'il décharge une seconde partie du flux sous pression depuis la seconde partie d'étranglement (76) dans une seconde direction qui est différente de la première direction en réduisant le flux au travers de la première partie d'étranglement (74) en utilisant au moins une première zone d'injection de fluide (80) ;
dans lequel la première partie d'étranglement (74) s'étend depuis un côté d'un fléchissement (72) de l'étranglement ; et dans lequel la seconde partie d'étranglement (76) s'étend depuis un autre côté du fléchissement de l'étranglement.

2. Système de propulsion (20) selon la revendication 1, comprenant en outre une pluralité d'injecteurs de fluide pouvant être commandés de manière indépendante (90, 92, 94, 96), incluant un premier injecteur de fluide (90) qui est positionné dans la première zone d'injection de fluide (80) à proximité de la première partie d'étranglement (74) et un deuxième injecteur de fluide (94) qui est positionné dans la seconde zone d'injection de fluide (82) à proximité de la seconde partie d'étranglement (76), dans lequel le premier injecteur de fluide (90) est opérationnel pour réduire le flux au travers de la première partie d'étranglement (74) ; et le deuxième injecteur de fluide (94) est opérationnel pour réduire le flux au travers de la seconde partie d'étranglement (76).

3. Système de propulsion (20) selon la revendication 2, dans lequel le système d'éjecteur(s) (50) est configuré de manière à ce qu'il dirige la poussée dans une direction de poussée primaire lorsqu'aucun injecteur de fluide n'est activé.

4. Système de propulsion (20) selon la revendication 2, dans lequel le système d'éjecteur(s) (50) est configuré de manière à ce qu'il génère un moment de lacet dans une première direction de lacet en augmentant le flux au travers de la première partie d'étranglement (74) en activant le deuxième injecteur de fluide (94) de manière à réduire le flux au travers de la seconde partie d'étranglement (76) ; et de manière à ce qu'il génère un moment de lacet dans une seconde direction de lacet en augmentant le flux au travers de la seconde partie d'étranglement (76) en activant le premier injecteur de fluide (90) de manière à réduire le flux au travers de la première partie d'étranglement (74).

5. Système de propulsion (20) selon la revendication 2, comprenant en outre :

un troisième injecteur de fluide (92) dans la première zone d'injection de fluide (80), lequel est situé à proximité de la première partie d'étranglement (74) et est positionné au travers de la première partie d'étranglement (74) à l'opposé du premier injecteur de fluide (90) ; et
un quatrième injecteur de fluide (94) dans la seconde zone d'injection de fluide (82), lequel est situé à proximité de la seconde partie d'étranglement (76) et est positionné au travers de la seconde partie d'étranglement (76) à l'opposé du second injecteur de fluide (94) ;
dans lequel le système d'éjecteur(s) (50) est configuré de manière à ce qu'il réalise les actions qui suivent :

la génération d'un mouvement de lacet dans une première direction de lacet en augmentant le flux au travers de la première partie d'étranglement (74) en activant le second injecteur de fluide (94) et le quatrième injecteur de fluide (94) de manière à réduire le flux au travers de la seconde partie d'étranglement (76) ; et la génération d'un moment de lacet dans une seconde direction de lacet en augmentant le flux au travers de la seconde partie d'étranglement (76) en activant le premier injecteur de fluide (90) et le troisième injecteur de fluide (92) de manière à réduire le flux au travers de la première partie d'étranglement (74) ; et
la génération d'un moment de tangage dans une première direction de tangage en activant le premier injecteur de fluide (90) et le deuxième injecteur de fluide (94) ; et la génération d'un moment de tangage dans une seconde direction de tangage en activant le troisième injecteur de fluide (92) et le qua-

trième injecteur de fluide (94).

6. Système de propulsion (20) selon la revendication 5, dans lequel le système d'éjecteur(s) (50) est configuré de manière à ce qu'il génère un moment de roulis dans une première direction de roulis en activant le premier injecteur de fluide (90) et le quatrième injecteur de fluide (94) ; et de manière à ce qu'il génère un moment de roulis dans une seconde direction de roulis en activant le deuxième injecteur de fluide (94) et le troisième injecteur de fluide (92).

7. Système de propulsion (20) selon la revendication 1, dans lequel l'étranglement fléchi (70) est continu entre la première partie d'étranglement (74) et la seconde partie d'étranglement (76).

8. Système de propulsion (20) selon la revendication 1, dans lequel la première partie d'étranglement (74) et la seconde partie d'étranglement (76) sont situées dans le même plan.

9. Système de propulsion (20) selon l'une quelconque des revendications qui précèdent, dans lequel la ligne centrale de l'étranglement fléchi (70) s'étend au travers de la flexion de l'étranglement, et la première partie d'étranglement (74) et la seconde partie d'étranglement (76) sont chacune angulées en direction de la ligne centrale.

10. Système de propulsion (20) selon la revendication 1, dans lequel l'éjecteur (52) est un éjecteur convergent (52) qui comprend une première rampe qui est configurée de manière à ce qu'elle dirige la première partie en direction d'une ligne centrale de l'éjecteur (52) et une seconde rampe qui est configurée de manière à ce qu'elle dirige la seconde partie en direction de la ligne centrale de l'éjecteur (52).

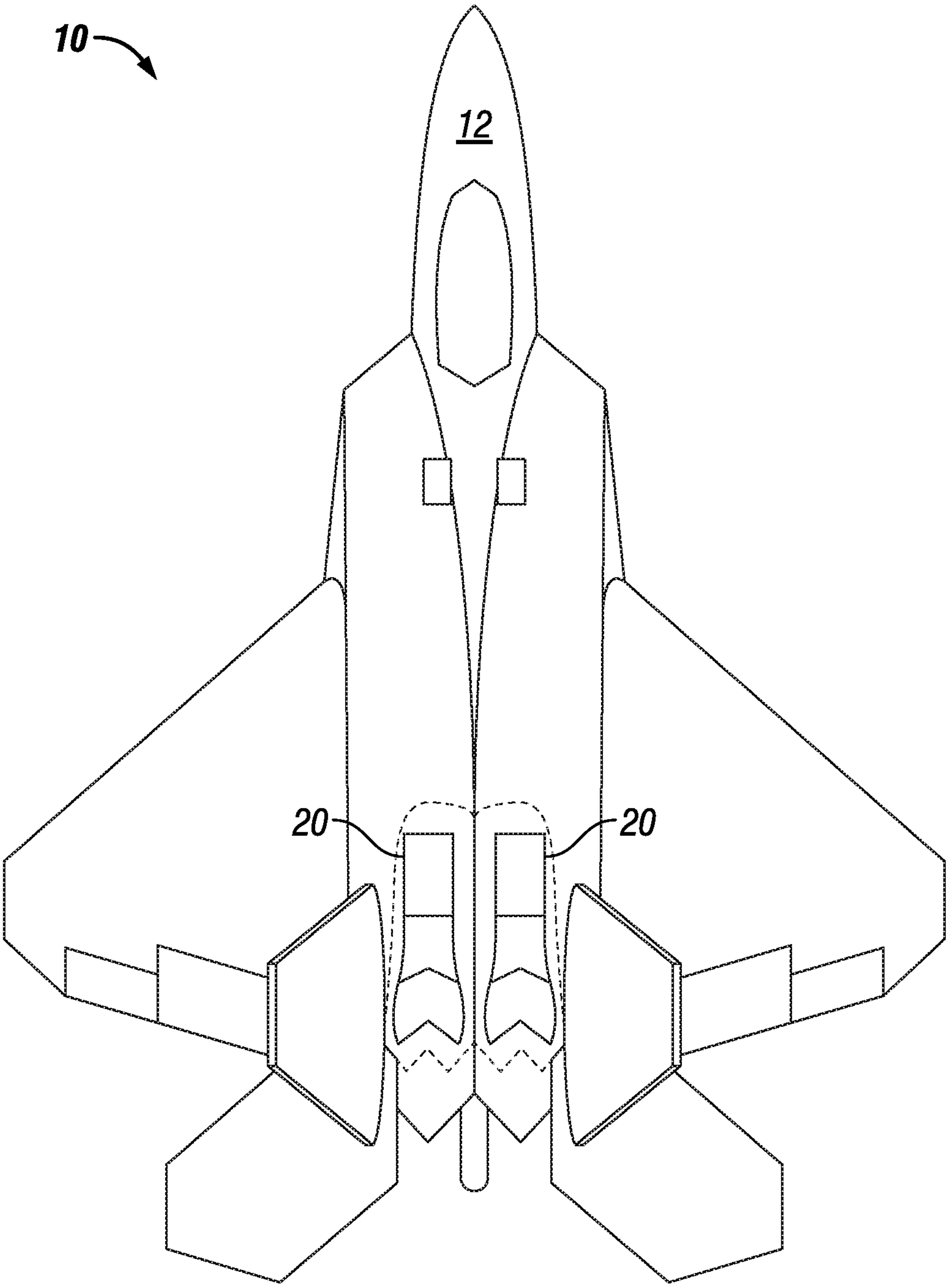

FIG. 1

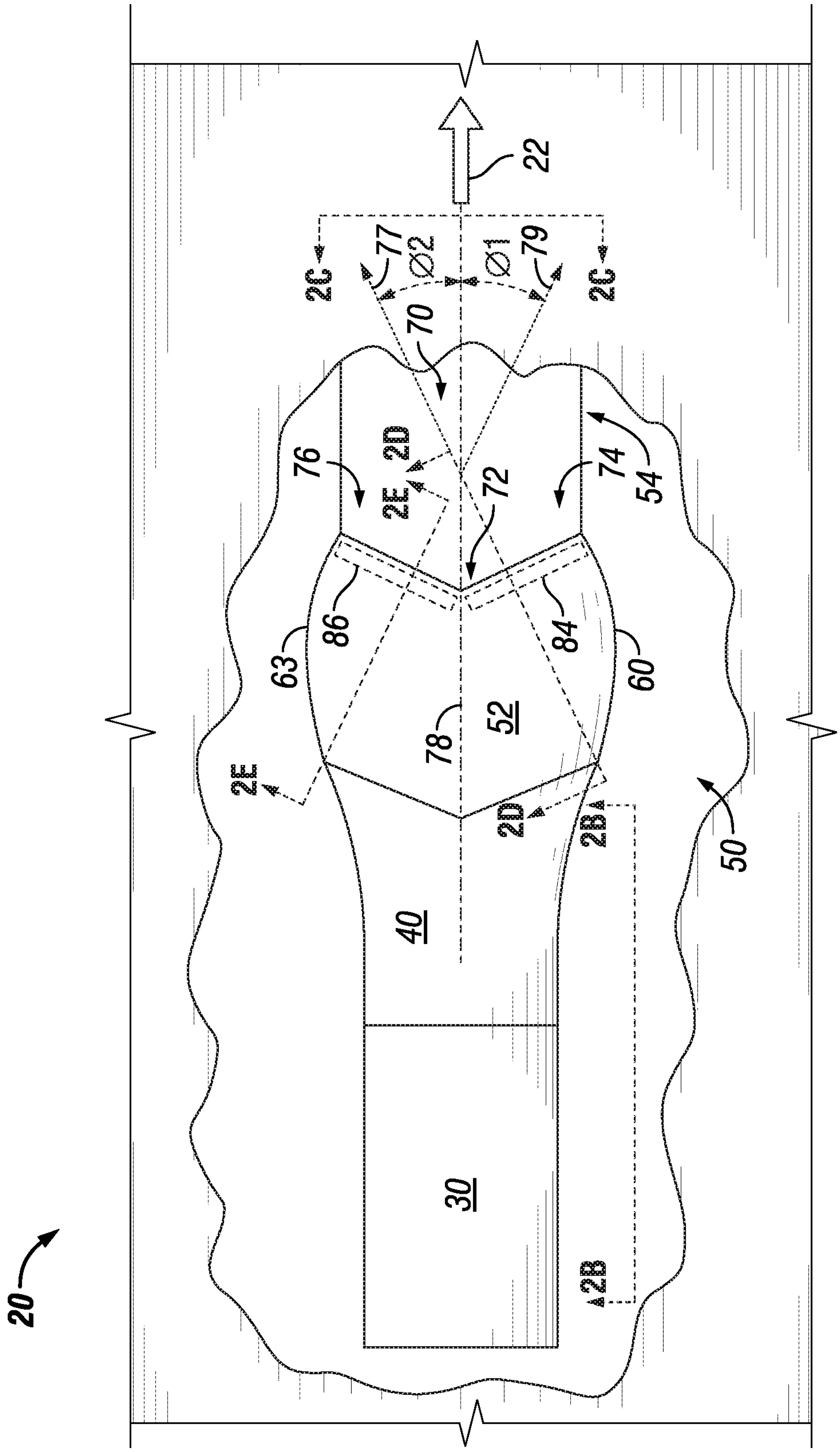
2C
2C
Ø2
Ø1
2D
2E
2E
2D
2B
2B

FIG. 2A

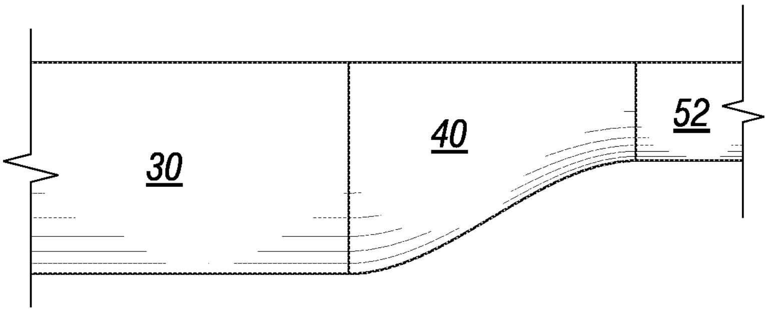

FIG. 2B

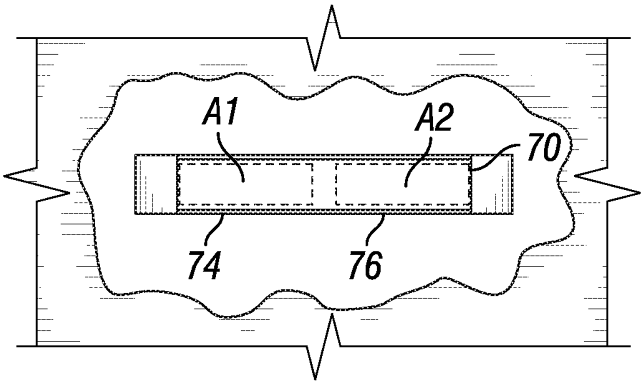

FIG. 2C

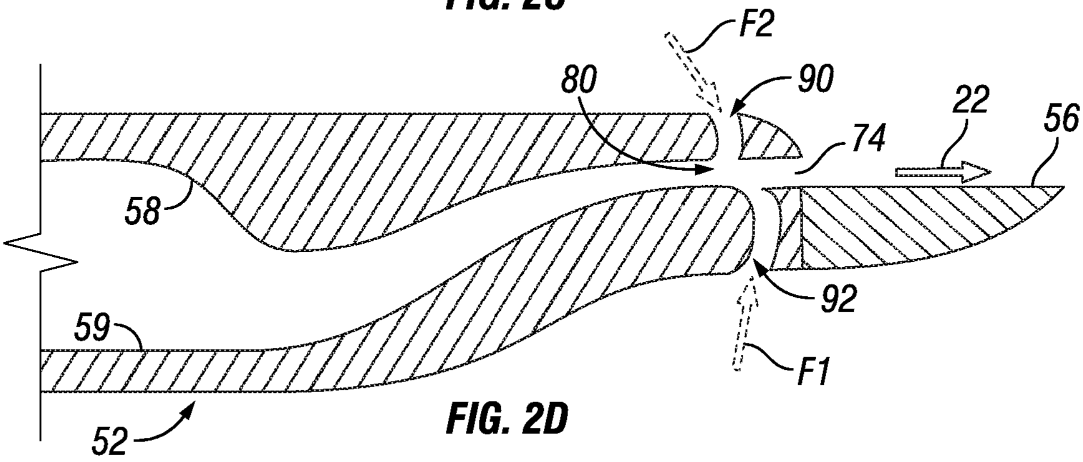

FIG. 2D

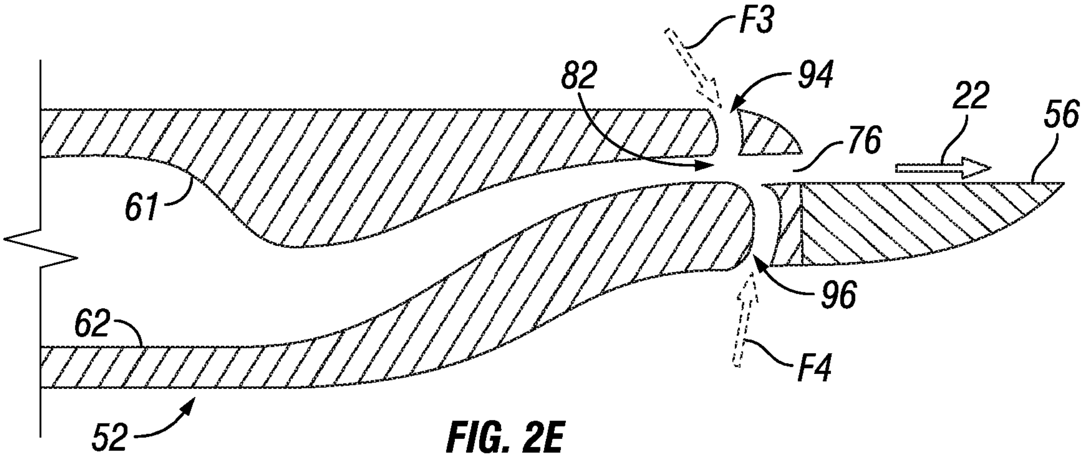

FIG. 2E

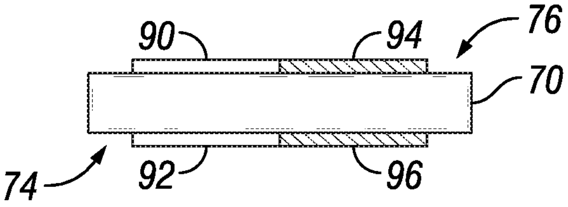

FIG. 3A

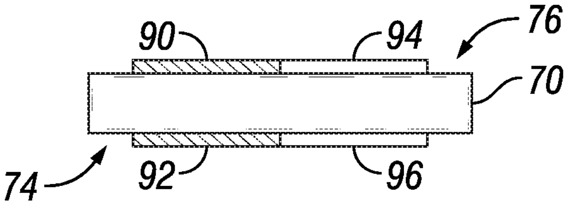

FIG. 3B

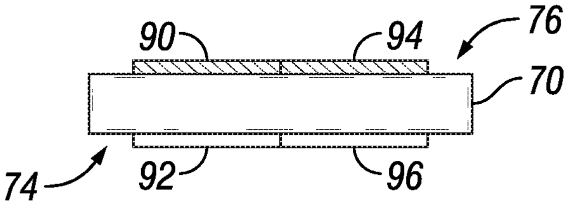

FIG. 3C

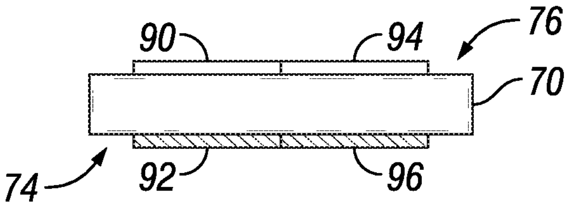

FIG. 3D

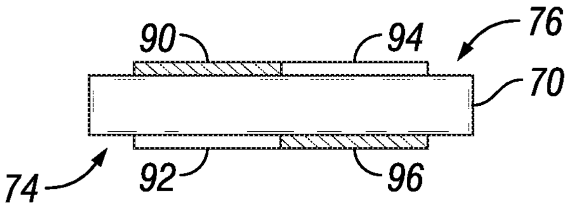

FIG. 3E

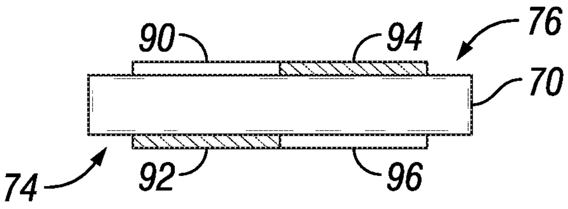

FIG. 3F

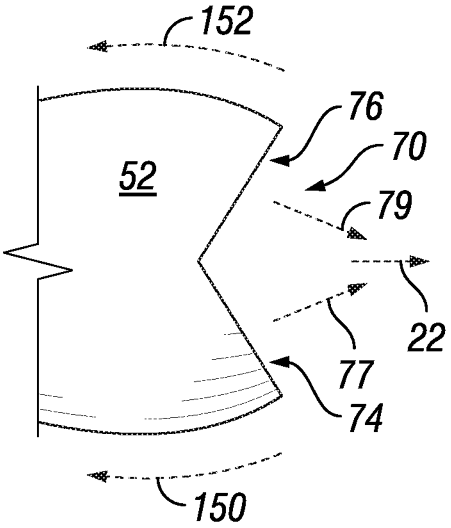

FIG. 4A

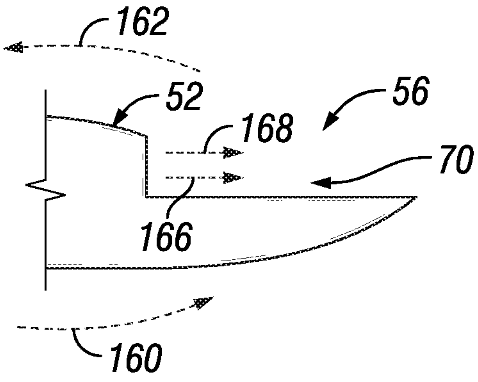

FIG. 4B

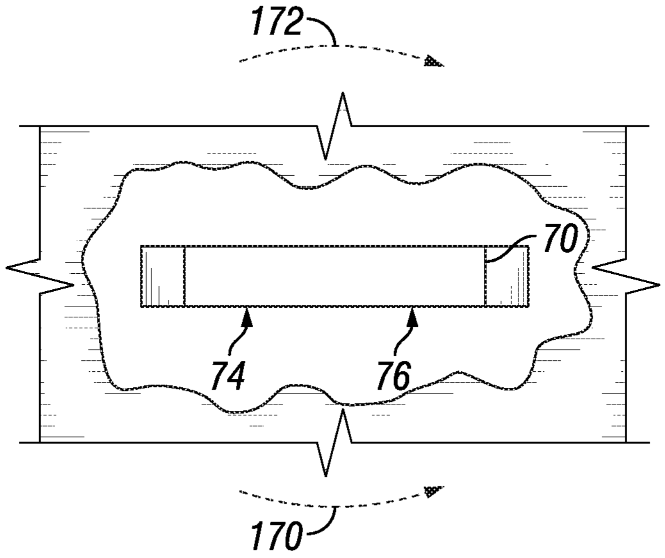

FIG. 4C

REFERENCES CITED IN THE DESCRIPTION

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